Midwater trawl technology
2001

CANADIAN FISHERIES

RESPONSIBLE FISHERIES

SUMMARY

MIDWATER TRAWL TECHNOLOGY 2001

Supported by Natural Resources Canada (PERD) Energy Efficiency Task

CATCH AND ENERGY EFFICIENT MIDWATER TRAWLS IN THE B.C. PACIFIC HAKE FISHERY

HIGH STRENGTH, LOW-DRAG TRAWL MATERIALS TESTED ABOARD RADIL BROS. FISHING VESSELS

Fisheries and Oceans Canada / Pêches et Océans Canada

INTRODUCTION

This project was carried out in 2001 to demonstrate that the use of modern rope and netting materials in the construction of midwater trawls can improve both catch and energy efficiency in the British Columbia Pacific Hake Fishery.

The following participants implemented the project on a cooperative undertaking:

- Fisheries & Oceans Canada (Responsible Fishing Operations)
- Fisheries Renewal British Columbia
- British Columbia Technology Assistance Program (TAP)
- Deep Sea Trawlers Association of British Columbia (DSTA)
- Radil Bros. Fishing Ltd.
- Cantrawl Nets Ltd.

BACKGROUND

The Pacific Hake Fishery

The hake fishery has been a mainstay of the BC trawl fishery for over twenty years. Over 50 trawlers, most of which are represented by the DSTA; participate in this fishery, which normally takes place annually from May to October. The fishery consists of a shore-based component which provides raw product to B.C. processing companies and an offshore, joint-venture component where Canadian trawlers supply fish to foreign factory vessels. The annual production usually ranges from 65 to 90 thousand metric tons, with a landed value ranging from $15 million to $22 million.

The hake fishery is a large volume, low price fishery that under normal circumstances requires trawlers to utilize large amounts of energy in its production. With the current high costs of diesel fuel there is an urgent requirement to reduce the drag of the midwater trawls to achieve energy savings. This reduced drag could also permit mid-sized trawl vessels to tow larger nets, which would be more efficient at catching hake.

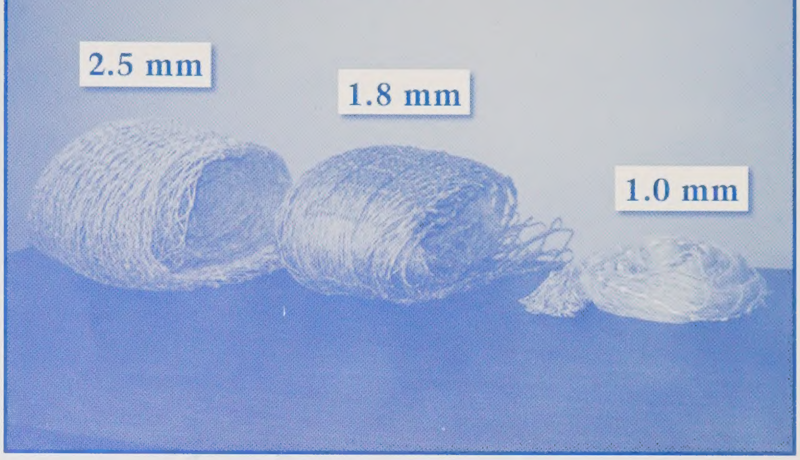
During the 2000 hake fishery the main body of hake, which migrates annually into Canadian waters, did not materialize. This resulted in trawlers having to fish the much less concentrated, resident stocks off the Queen Charlotte Islands and in Queen Charlotte Sound. The vessels using nets with large mouth openings and/or the ability to tow at higher speeds were the only ones that obtained reasonable production for the season. Apart from the problems encountered in 2000, shore processors have a requirement to even out daily fish landings and have wanted the trawlers to fish earlier in the morning and later in evening, when the fish are more scattered. In addition larger landings of hake are needed earlier and later in the season in order to keep plants fully operational, providing a longer season. Hake are also scattered at these times of the year and are more difficult to catch. To meet this requirement larger trawl openings are again required. For most trawlers, particularly smaller mid-sized vessels, the only options to fish with a significantly larger trawl are to increase the vessels power, operate in conjunction with another vessel (pair trawling), or to use a trawl constructed with high strength/low drag materials.

Joint-Venture Hake Fishery

Modern High Strength Materials in the Fishing Industry

Spectra/Dyneema filaments are used to produce very high strength ropes and twines. Because of this high strength, much smaller diameter twines can be used to produce netting which will move through the water with much less resistance than traditional materials. Although these products have been used in commercial fishing gear, particularly in Europe and parts of the United States, their application in the British Columbia trawl fishery has been very limited due to their high costs.

Figure 1
Visual Comparison of Net Cones



Recent developments in polyethylene filaments have resulted in twines, which, in terms of strength, fill the gap between traditional polyethylene twines and the Spectra/Dyneema materials previously mentioned.

The use of these materials in the construction of midwater trawls, which are normally designed to obtain large openings, can result in a significant reduction in diameters of the ropes and twines used in various parts of the trawl. Although the costs of these materials are higher, and much higher for Spectra/Dyneema products, than traditional materials, the reduction in both the weight of the gear and the towing resistance can have very positive benefits in terms of reduced fuel consumption, reduced loads on winches and gear handling equipment, and improved safety through reduced deck loading.

THE PROJECT

The project was carried out in four phases as follows:

Gear Design and Construction

Based on computer analysis, two nets of 912 - metre circumference (Cantrawl Model 912m x 600HL) were constructed for tests aboard the FV "Sea Crest" (930 HP) and the FV "Royal Canadian" (750 HP). The Sea Crest net was made with standard ropes (12 strand braided polyester) and was constructed with an easily removable experimental test section in the 8" to 4" bellies. The Royal Canadian net was made with a Plasma rope section (similar to, but stronger than Spectra) and also included an experimental test section. An additional experimental section, representing currently used materials, was also constructed for testing. The experimental test sections are described in Figure 2.

Towing Tank Testing

Three net cones (see Figure 1) were constructed at Cantrawl Nets Ltd. for comparative resistance measurements in the BC Research Ocean Engineering Centre Towing Tank. The cones were made from 4" kc netting with 84 meshes at the front, 24 meshes at the back, a length of 30.5 meshes and mounted on a 15' - 5" circumference steel hoop for each trial. The netting materials tested were 2.5 mm Euroline Premium, 1.8 mm Euroline Premium Plus, and 1.0 mm Euroneema. Test runs from zero to 4 knots were made for each net cone, with the towing resistances recorded by computer.

Experimental Fishing Trials

Experimental fishing trials were carried out in the Strait of Georgia with the FV "Royal Canadian" and the FV "Sea Crest" using the nets described above. The nets were fished without codends, but the ends of the 4" bellies were closed. Forty-fathom (240 ft) bridles were used for both nets. The Sea Crest conducted trials with and without wing weights, while the Royal Canadian completed the trials without weights. The Royal Canadian used the trawl constructed with Plasma ropes in the front end, while the Sea Crest used the net with standard polyester ropes. Trials were carried out over speed ranges from 2 to 3.5 knots, with each vessel testing each of

the three experimental net sections described in Figure 2. The Strait of Georgia was used for the tests due to generally good sea conditions and its close proximity to the vessels homeport in Steveston. Negative factors, however, included the variable cross-tides, which impacted the gear and made it difficult to replicate tows under the same conditions. Gear geometry, gear resistance, fuel consumption, engine rpm, and exhaust temperature were measured and recorded for each tow. Relevant navigation data, weather and sea conditions were also recorded.

Figure 2	EXPERIMENTAL BELLY SECTIONS		
	8"	5-1/2"	4"
E/EP **Additional Section** Cost Factor 1.03 Weight Factor 0.72	Euroline 3 mm	Euroline 3 mm	Euroline Premium 2.5 mm
EP/EP+ **Sea Crest** Cost Factor 0.88 Weight Factor 0.48	Euroline Premium 2 mm	Euroline Premium 2 mm	Euroline Premium + 1.8 mm
Euro **Royal Canadian** Cost Factor 2.07 Weight Factor 0.33	Euroneema 1.5 mm	Euroneema 1.5 mm	Euroneema 1.0 mm
PE **Canadian No. 1** Cost Factor 1.0 Weight factor 1.0	Polyethylene 4mm	Polyethylene 4mm	Polyethylene 4mm

Commercial Fishing Operations

Commercial fishing operations of the Royal Canadian and Sea Crest were monitored throughout the west coast hake fishery from May to September, 2001. Both vessels used the new trawls with the experimental net sections shown in Figure 2, as well as their smaller, conventional super-mesh trawls. In addition, the operations of a third vessel, the FV "Canadian No. 1" (640 HP), using a modified Cantrawl net very similar to the new trawls, and a newer design super-mesh trawl, were monitored. The Royal Canadian and the Sea Crest were principally involved in the joint-venture fishery while the Canadian No. 1 fished for a shore-based plant.

PROJECT RESULTS

Warp Tension Meter & Trawl Door with Spread Sensor

Towing Tank Testing

The graph in Figure 3 shows the measured resistances of the three net cones, overlaid on a plot of computer-estimated resistances for the same twine sizes, plus those for 2.5mm and 4.0mm twine. The graph clearly shows the drag reductions that can be achieved by using smaller diameter twines in trawl nets.

Gear Design and Construction

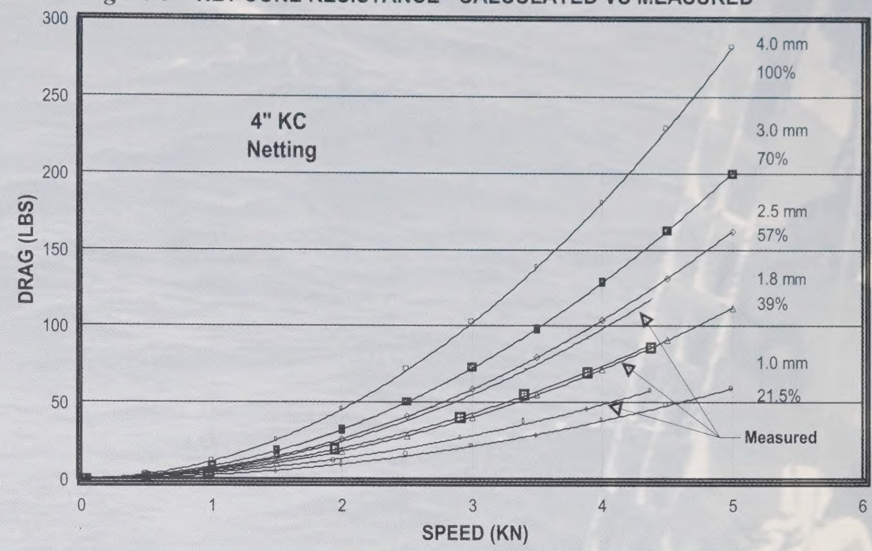
The cost and weight factors for the three experimental belly sections, based on an equivalent section made entirely from 4mm PE (polyethylene) netting, are shown in Figure 2. While the Euroneema section is only one third of the weight of a 4mm PE section, and had the lowest drag during the experiment, the cost is twice that of the 4mm netting. A very effective substitute for the 4mm PE section appears to be the EP/EP+ section, with half the weight, a 12% cost saving and very good results in terms of drag. The small diameter Euroline Premium, Euroline Premium Plus and Euroneema twines showed little wear after the completion of one hake season. The Plasma rope section on the Royal Canadian net was 27% of the weight and double the cost of a standard rope section made from 12-strand braided polyester.

The initial computer predictions during the planning stage of the project indicated that a relatively low reduction of about 3% in overall gear drag would be obtained with this substitution. For this reason and the requirement to transfer nets back and forth from one vessel to another, comparison studies were done only with the experimental net sections.

Monitoring Equipment

The NetMind Trawl Monitor System functioned well throughout the project, indicating when desired catches were achieved and providing continuous monitoring of the door depths and door spreads. The catch sensor, on its own, proved to be a time and fuel saving device as the vessel skippers often found that, by responding to the catch alarm bell, they achieved their desired catches much sooner than they would normally have expected.

Figure 3 - NET CONE RESISTANCE - CALCULATED VS MEASURED

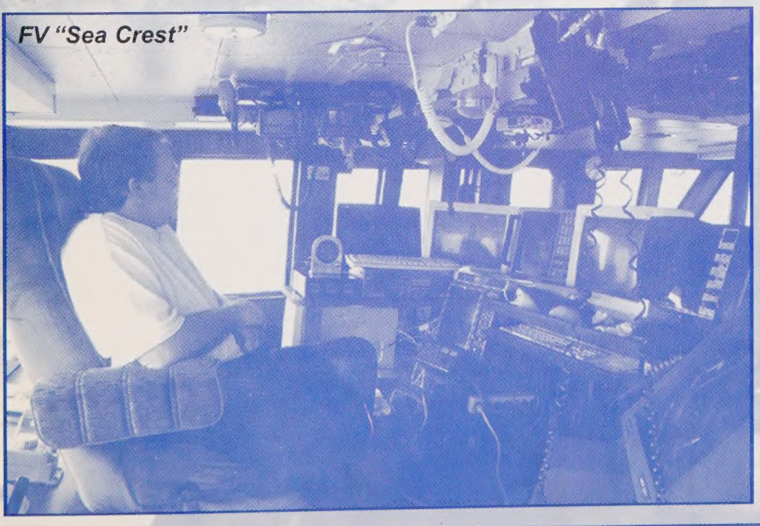


The engine monitoring systems provided continuous recording of GPS data, fuel consumption, and exhaust temperatures. The FloScan fuel meters functioned satisfactorily and provided good relative fuel consumption data for the individual vessels. Due to time constraints, the fuel meters were not calibrated to provide exact readings and could not be used to provide fuel comparison between the vessels. Fishermen, in the past, have used exhaust temperature readings to indicate the load on their engines. This proved to be the case during this project and it was found that the exhaust temperatures very closely paralleled the fuel consumption.

EXPERIMENTAL FISHING TRIALS

Comparative Gear Resistance

Warp tension readings were obtained from a three-wheel warp tension meter mounted on the starboard warp of the Sea Crest and the port warp of the Royal Canadian. The readings were taken manually from a digital read-out, averaged and logged. To calculate the total resistance, the logged numbers were doubled and adjusted for trawl depth and warp angle, based on the warp length and door spread. Comparing the total gear resistance with each of the three experimental sections inserted, the EP/EP+ section provided a reduction of 6.3% - 12% versus the E/EP section. The Euroneema section, in turn, provided a reduction of 12.6% - 16.5% versus the E/EP section.



FV "Sea Crest"

Commercial Fishing Operations

A summary of the information obtained from the three vessels is included in Figure 4 - Trawl Comparisons During 2001 Hake Season. The sketches showing an approximation of the experimental and conventional nets for the Sea Crest and Royal Canadian (depicting distances from the Sea Crest data) give a pictorial representation of the much greater frontal area obtained by the experimental nets over the conventional nets. The table for the Sea Crest compares the experimental net, with the Euroline Premium/Euroline Premium Plus (2mm and 1.8mm) experimental belly sections,

against the vessels conventional supermesh trawl, with 4 mm netting in the belly sections. At approximately the same speeds, RPM, exhaust temperatures and fuel consumption, the experimental net obtained an increase in door spread of 33% and in the net vertical opening of 80% over the conventional trawl. Based on an elliptical approximation, the frontal area increase was 139%.

The table for the Royal Canadian shows a similar comparison. In this case, the Royal Canadian was using the Euroneema netting (1.5mm and 1.0 mm) in the experimental belly sections. The door spread increase was 22% and the net vertical opening was 85% yielding an approximated area increase of 126%. The table shows a fuel increase of 15% for the experimental net, but due to a computer problem, the fuel consumption was only recorded for a few tows with the experimental net.

The Canadian No. 1 season averages are shown in the third table. During the first part of the fishery, the modified Cantrawl net was fished with its existing 4mm belly sections. With this arrangement there was a reduction in door spread (8%) and an increase in vertical opening, compared with the supermesh trawl. For the rest of the season, the experimental Euroline/Euroline Premium section (2.5 mm and 2.0 mm) was installed. In a similar comparison, the smaller twine sizes in the belly sections of the modified Cantrawl net provided an increase in door spread of 4% and vertical opening of 22% resulting in an approximated frontal area increase of 27%. In all three cases, the speed and engine parameters were similar.

Catch quantities were not analyzed on a quantitative basis for two reasons. Firstly, in the joint-venture fishery the factory trawlers set catch limits of approximately 25 - 30 tons. Secondly, the nets were fished under different conditions; i.e. during the early part of the season the hake were in shallower water, which was more restrictive to the large nets and the fish were more concentrated and easily caught in quantity by the smaller conventional nets. When the fish moved into deeper water, where they were more scattered, the large nets were able to maintain the catch rate and in many instances out fish other vessels using smaller nets by factors of two to three. The Sea Crest and Canadian No. 1 used the large nets in the "Gulf" Hake Fishery (Strait of Georgia) with similar results.

From the engine data collected and graphed, it was found that the data points for fuel consumption and exhaust temperature closely parallel each other. This gives every indication that by applying a constant to exhaust temperature readings, fuel consumption can be closely approximated by an exhaust temperature monitor, without the added cost of a fuel monitoring system.

Figure 4
Trawl Comparisons During 2001 Hake Season

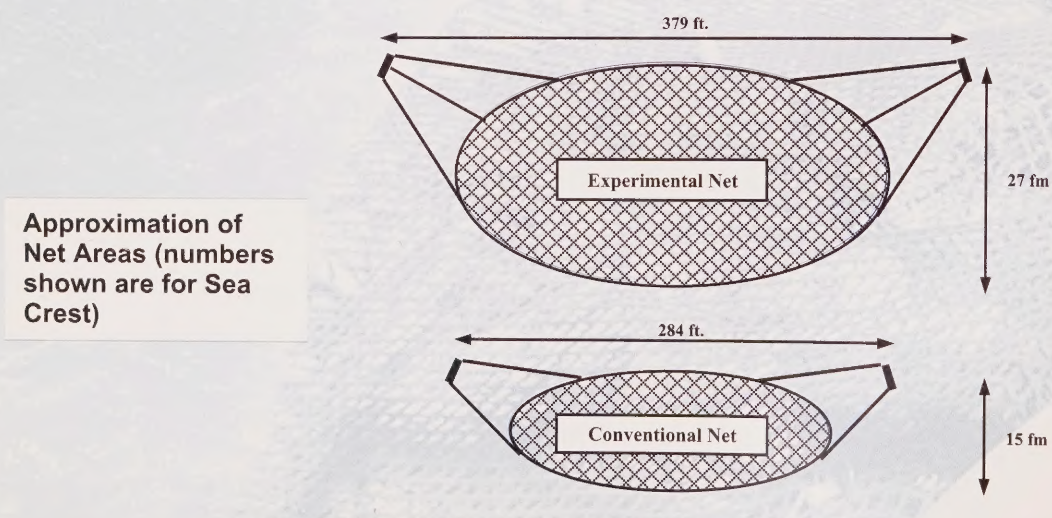


Figure 4 - continued

Trawl Comparisons During 2001 Hake Season

FV "Sea Crest" Season Averages

	Speed (knots)	RPM	Temp (F)	Fuel (USgph)	Doorspread (ft)	V. Opening (fm)
EP/EP+	2.81	1314	391	19.11	379.10	27
Conventional	2.72	1331	397	19.68	284.42	15
Increase	3%	-1%	-2%	-3%	33%	80%

Area increase 139%

FV "Royal Canadian" Season Averages

	Speed (knots)	RPM	Temp (F)	Fuel (USgph)	Doorspread (ft)	V. Opening (fm)
Euroneema	2.64	528	506	20.8	340.94	24
Conventional	2.61	515	486	18	279.04	13
Increase	1%	3%	4%	15%*	22%	85%

Area increase 126%

*small data set due to computer problem

FV "Canadian No 1" Season Averages

	Speed (knots)	RPM	Temp (F)	Fuel (USgph)	Doorspread (ft)	V. Opening (fm)
4mm PE	2.84	506	598	22.3	310.69	22
E/EP	2.79	504	594	22.8	351.57	22
Supermesh Trawl	2.86	500	590	21.9	338.25	18
Increase	-2%	1%	1%	1%	4%	22%

Area increase 27% (based on E/EP)

CONCLUSIONS

The project conclusions are presented in point form as follows:

- Towing tank testing of net cones and computer analysis indicate that, through the use of the smaller diameter new netting materials, the towing resistance of a net section can be reduced by as much as 78% when 4mm netting is replaced with 1mm netting.
- The experimental fishing trials provided gear resistance data which showed that by replacing the 3mm and 2.5mm, 8" -5 - 1/2" - 4" belly sections with 1.5mm and 1.0mm sections, the total gear drag can be reduced by up to 16%, with similar fuel savings.
- The commercial fishing operations phase of the project demonstrated that the experimental nets could achieve much greater door spreads and net openings than the smaller conventional nets, using similar power output and energy consumption. The large nets were used when the fish were more scattered and were able to maintain high production levels, often at a catch rate two to three times those of vessels using smaller, conventional nets.
- Use of new, high strength netting twines now available provides a cost effective way to reduce energy costs for existing trawls, to modify them to larger opening nets, or to replace them with new larger trawls. For example, 4mm polyethylene net sections can be replaced with the lighter, thinner and stronger Euroline Premium Plus (or equivalent) net sections with a 12% cost saving.
- Gear monitoring systems are a real asset to trawling operations and particularly in the case of the catch sensor, can save time and fuel.
- The engine monitoring systems (fuel consumption, RPM and exhaust temperature) provided useful information to the skippers in addition to collecting project data. The temperature monitor demonstrated its potential as a less costly alternative to a fuel monitoring system.

RESPONSIBLE FISHING SUMMARY - MIDWATER TRAWL TECHNOLOGY

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